Social Scientist

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Source: *Social Scientist*, Vol. 11, No. 6 (Jun., 1983), pp. 48-60
Published by: Social Scientist
Stable URL: http://www.jstor.org/stable/3516908

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Dialectical Contradiction in the Sciences

THE WORLD exists independently of the consciousness of man and it is knowable. Thought is an attribute of matter in its highest form of organisation as found in the human brain. Thinking and cognising are forms in which man grapples with the world around him. Knowledge is the result of social practice and is tested in practice. It was Karl Marx's great service to philosophy that he recognised this vital relation between knowledge and practice, between truth and practice.

As human society develops man discovers more and more new properties and relationships in the world around him. He tries to detect and express the inseparable characteristics of material entities. The concepts that express these invariant properties are shaped by man in the process of his creative activity. These are the philosophical categories which express such relationships as motion, space, time, causality, regularity, necessity, chance, contradiction and so on.

Categories are instruments by which man tries to grasp reality in his consciousness. Like all his other instruments, categories represent stages in the development of his cognition and practice. The material entities through which matter exists are not static, but they are in constant interaction and change. Hence the concepts through which man reflects the world in his consciousness should also be interconnected, interdependent, and must on occasion *pass into one another*. As Lenin said, "Human concepts are not fixed but are eternally in movement, they pass into one another, otherwise they do not reflect living life."

Though categories represent stages in the development of cognition and practice, they nevertheless reflect objective reality. This is because they represent the essential features of reality. There are some who call themselves Marxist but who deny that the laws of dialectics operate in Nature. They hold that the laws of dialectics apply only to thinking and the way we assemble information, that "... they are principles for maintaining informativeness and removing

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illusion and fantasy."[1] Neil Smith states that "...the dialectic cannot be conceived as existing outside human experience of the world. To seek a dialectic in nature, divorced from the human appropriation of nature, is to indulge in metaphysics."[2]

The test of dialectics, as Engels said, is in nature. The question that we should ask is whether processes in nature are characterised by the unity and struggle of opposites, whether they pass through stages of quantitative growth and qualitative leaps, changes from one quality into its polar opposite, and so on, independent of observation by human beings. All the sciences show that the principles of dialectics operate in natural processes. The principles of dialectics have been abstracted from the widest range of human experience. It is in this sense that the laws of dialectics have been described as the most general laws of development of nature, society and thought.

Contradiction

Of all the laws of dialectics the central one is concerned with the unity and struggle of opposites and the corresponding category of contradiction. I shall consider in this paper only this central feature of dialectics and show how this particular law is manifested in nature. I shall also try to show how the operation of this law in nature has its reflection in our thinking, in the contradictions that arise in our theories at crucial stages in the development of the sciences, and how these contradictions are resolved.

The ancient Greek philosophers of the Milesian school had grasped the essence of reality when they stated that change was fundamental in nature. Heraclitus said, "All things flow, all change. It is impossible to enter twice into one and the same stream." It was in a sense natural to proceed to the next step of understanding the motion of things as a unity of opposite features, and indeed the Eleatic philosophers grasped this essence of motion. But being incorrigible idealists, having expressed motion in terms of contradictions they tried to use this to disprove motion itself. Movement itself is a contradiction and so movement cannot be real, they declared.

Watching a bird in flight across a river the ancient philosopher must have noticed that what was here is changed to there. Here and there are opposite terms (exclusive terms). The flight of the bird therefore unites these opposites. This idea was developed by Zeno, one of the best known of the Eleatics, in the form of four paradoxes, to show that motion was a contradiction. The famous paradoxes of the arrow in flight and of Achilles and the tortoise give the general line of argument. The paradox of the arrow runs like this. An arrow in flight has to be somewhere, say the arrow A is at the point B. But then since it is in flight the arrow cannot be at B. Thus we have the contradiction: The arrow A is at B and the arrow A is not at B. We shall see later how this contradiction is resolved, but we shall now

merely remark that Zeno used this argument to show that motion was a mere illusion.

Hegel's Contribution

It was one of the achievements of Hegel to have culled together the history of dialectics from many civilisations and presented it in a systematic form. The word dialectics comes from the Greek 'dia' meaning to split into two, opposed, clashing; and 'logos' meaning reason. The literal meaning is to reason by splitting into two.

Hegel considered the movement of thought and detected the pattern of thesis, antithesis and synthesis through which it moves. Being an idealist he considered thought as primary and the movement of thought (or Thought, with a capital T) as the driving force in the world. According to him this dialectic of opposites clashing and uniting was the driving force behind the development of the Absolute Idea. He had grasped the essence of development as the clashing of opposites, development as being the outcome of the unity and struggle of opposites. But he had grasped reality upside down.

On January 16, 1858, Marx wrote to his friend Engels reporting on his progress with his study of profit and value. He said, "I am getting some nice developments, e g, I have overthrown the entire doctrine of profit as previously conceived. In the method of working it was of great service to me that by mere accident ... I leafed through Hegel's Logic again."

Hegel had recognised that to have a concept of a thing it was necessary to grasp the thing, to get hold of it and to hold it still. This was fine. But the question Marx asked was: "What if the thing is in motion, and this motion is part or all of its truth?" Can we then hold the thing still? Should we give up all attempts to hold it, and sink into a hopeless relativism? Marx gave the answer as follows: "The *fixed* presuppositions themselves become fluid in the course of development. But only by holding them fast at the beginning is their development possible without confounding everything."[3] This fluidity in the content of thought and concepts will show themselves up when we deal with some of the examples of the resolution of contradictions in the sciences

Examples from Science

In the smallest known particles and structure of physics, such as atoms, protons, neutrons and electrons, we have the opposite aspects of electric charges, magnetic moments and spins, attraction and repulsion, fusion and fission and so on, but more importantly, these opposites are seen to change from one into its other. For example, there is the spontaneous flipping of the electron going around the hydrogen nucleus from positive spin to negative spin (giving out the characteristic 21 cm radiation of hydrogen), and the proton changing

into the neutron and vice versa, which is an essential part of the nucleus of an atom remaining stable. The existence of the atom depends on this inner movement, and when the atom does change by fission or fusion, this inner movement plays a major part in this development.

At the higher and more complex level of molecules we again have qualities of opposite polarity united in these entities. The bonds between the different atomic nuclei that go to form the compound molecule is the coming together of oppositely charged structures. Again though each molecule is neutral in its totality, it exhibits opposite polarity, opposite parts of the same molecule being positive and negative. The same molecule may therefore come in different forms and pass from one form into its opposite form, e g, the cyclohexane molecule flipping into the chair form from the boat form and vice versa.

When we come to the next higher level of complexity, the molecules and structures representing life, in the biological sciences, this law of contradiction is even more evident. In fact the life histories of organisms may be described as the changing dynamic equilibria between cell division and cell death. Within the very process of cell formation we see the splitting of the one into two, the formation of two poles within the cell. During the prophase stage of mitosis the centrosome divides and the two daughter centrosomes move apart, as though by repulsion, to opposite sides like the poles of a magnet. They draw the divided chromosomes into separate halves of the cell. The life of the cell itself is a unity of the opposite processes of assimilation and dissimilation (accretion and discharge of matter and energy).

In the functioning of the body we have opposite movements, like the opposed forces of the triceps and biceps in moving the hand, the opposed forces of the muscles for shutting and opening the jaws (which do not coordinate when we get tetanus) and hundreds of other such opposing forces. Every movement is due to, what Sherrington calls, the enervation of antagonistic muscles. In old age it is the lack of this coordination which produces Parkinson's disease. Evolution is again a unity of stability and change. The key problem in heredity is to explain the inheritance of likeness as well as the phenomenon of variation. We see the same sort of unity of opposites in the higher stages of life, colonies of living things and social structures. In animals we see predation as well as symbiosis, in human societies we see class struggle. But this has been studied in great detail. It does not need stressing that the strife of opposite plays the key role in the development of life at this stage, that is, in the development of history.

Just as we give credit to the idealist philosopher Hegel for having pointed to the dialectic of unity and struggle of opposites, we

should acknowledge the contribution of another idealist philosopher Immanuel Kant in understanding that the stars are not permanent entities existing unchanged for eternity, but are evolving systems. He postulated that the stars were evolved out of a primary Nebula. The modern theory of stellar evolution is a far cry from this concept. But the essence that stars arise and pass away has been retained in these theories. Stellar evolution gives the most magnificent illustration of the operation of the laws of dialectics. In particular, it illustrates the law of contradiction.

The condensation model, which is the most widely accepted, assumes that stars are formed by the condensation of huge clouds of gas and dust found in the galaxies. Gravity is the main force at this stage. If the cloud is above a critical size it starts condensing due to the gravitational attraction of the parts for each other. Smaller clouds dissipate due to the motion of the particles. Note that it is at a critical quantitative stage that dissipation becomes condensation —an example of quantity changing to quality. This critical size happens to be a mass equal to hundreds of ordinary stars. Hence from such a cloud hundreds of stars can be formed.

At a certain stage of condensation the cloud breaks up into sub-units called protostars because of instability. Instability in the cloud is a manifestation of its inner motion. Though this has not yet been thoroughly understood, unlike in the case of the process of evolution of stars from the protostars, let us point out that had it not been for opposing inner movements the dust cloud need not have fragmented.

In the next stage the fragment gets further condensed and becomes an object which emits light, i e, a star. Here as the condensation proceeds the gas gets heated up and massive pressure is built up. It is this pressure which keeps the system stable without collapsing due to gravity. The process of heating up continues until the temperatures are high enough to start nuclear processes within the central region. Here again there is a critical stage when the repulsion between the hydrogen nuclei is broken by the energy of the particles so that they can coalesce to form helium nuclei. This is another example of the law of quantity getting transformed into quality. But this is also an example of the play of the opposing forces of thermal pressure and gravitational attraction. The star has become a thermonuclear reactor.

The star remains in this stage, converting hydrogen into helium, for a long time (of the order of thousands of millions of years). This is called the 'main sequence phase' of the life of the star. During this phase the star is in equilibrium. But gradually inhomogeneities develop within the core of the star as the hydrogen gets depleted and the content of helium increases. The star adjusts to the new situation by the expansion of its outer part and the further condensation of

the core. The temperature of the core rises further until new processes start within the interior. This is the process of conversion of helium into carbon. Again opposite forces are at work, the attraction due to gravity and the pressures developed by the new energy source. The new kind of nuclear fusion of helium nuclei into carbon nuclei is itself the outcome of the repulsive forces of the nuclei being countered by the high energy of the particles. The star is now said to be in the red giant stage. Of course the exact mode of development of the star depends on the mass of the star, and its internal motions.

Phase of Contraction

If the mass of the star is not much larger than that of the sun, (less than one and a half times the mass of the sun) the star enters a new stage after the helium has got exhausted. It enters a phase of contraction until a new balance is provided to gravitational attraction. It is a continual fight against gravitational attraction, the engine of opposition being provided by different modes of energy production. Now matter becomes so compressed that it exhibits a new property. Matter becomes quantum mechanically 'degenerate', and the pressure starts increasing with the density. This new pressure keeps the star from collapsing into a point. This is called a white dwarf. The white dwarfs are stars which have reached an extremely high density. One cubic metre of such material would weigh about 170000 metric tons. White dwarfs are very faint stars and they are not visible to the naked eye. The star Sirius (Vyadh) has a companion which is a white dwarf. In the white dwarf again there are opposing forces at play, gravitational attraction tending to make the star collapse, and the pressure provided by degenerate matter, preventing this.

However, there is yet another category of stars. Stars which are heavier than the critical size described above enter a further stage of compression where the matter gets converted into neutrons, the protons and electrons getting pushed into each other to form this electrically neutral material. The star is now said to be a neutron star. Neutron stars have densities around 100 times the density of white dwarfs. Here again gravity and pressure act in opposite senses to keep the star in this stage.

In the case of heavier stars, they can explode into a supernova, or they can get compressed until they become smaller than a critical size called the Schwarzschild radius. A supernova results when the inner part of the star, its core, collapses and releases energy to such an extent that the outer region, its mantle, explodes. In a sense this is the death of the star. The inner part becomes a white dwarf or a neutron star (pulsar). The outer mantle continues in a new form of motion. Inner contradictions are still at work. The second possibility of continual shrinking of the star till it becomes smaller that its

Schwarzschild radius would result in what is called a black hole. Einstein's theory of gravitation predicts that when a body has become smaller than its Schwarzschild radius, it has no way to move except inwards. A star which has exhausted its nuclear fuel would go into this stage if its mass is above a critical size. A black hole would not allow any light to come out of it because of its intense gravitational pull. Black holes have not been observed, but their existence has been predicted by theory.

We have seen how the law of struggle of opposites operates in the evolution of the stars, the largest observed material structures in the universe. Larger structures like galaxies and clusters of galaxies also exhibit such motions. Going in the opposite direction towards the smallest structures, we see the laws of dialectics being vindicated in quantum theory. The opposites of necessity and chance are of greatest use in unravelling quantum phenomena. We see layer below layer of necessary law and statistical law in nature. Dialectics enables us not to get lost in the maze either by trying to reduce every law into a statistical law or on the other hand by trying to reduce every law into necessary mechanically given causal formulations. Particles exhibit wave properties and waves exhibit particle properties. The only way to understand elementary material structures is to see them as a unity of the polar opposites of waves and particles. Indeed the law of unity and struggle of opposites is universal in nature.

What is the result of this for the theories we frame about the universe? The result is that in the case of every scientific theory, at a crucial stage of its development we arrive at contradictions. These contradictions are not verbal defects that may be brushed under the carpet, but represent deep properties of reality, and have to be *resolved.* Formal logic abhors contradiction. Dialectical logic teaches us how to work with contradictions and resolve them.

Formal logic deals with concepts and relations that are fully formed and established in their content and range. The material that formal logic works with should have fixity of content. Furthermore, formal logic deals with the expression of relations, contents and operations by means of symbols (language) presupposing the stability of what they express. Language, however, is only one aspect of thought. Practice is another important reality of thought. Concepts themselves are worked out on the anvil of practice, and are therefore undergoing change all the time. In fact in the hands of a perspicacious scientist the content of thought undergoes radical change. The great physicist Niels Bohr once declared, "What is needed is some crazy idea to sort out the present problems."

Dialectical logic recognises that "a statement consisting of contradictory or opposed statements, that is to say, statements which deny each other should not, and indeed cannot, always be rejected as false on purely logical grounds".[4] In the process of grasping reality

what is likely to be of more use is dialectical logic. Scientists instinctively deal with contradictions and resolve them without caring for the prohibitions of formal logic. After the concepts have been cleared up and shaped by the great geniuses of science, the results are best presented using formal logic.

Example from Geometry

The shaping of concepts on the anvil of social practice is illustrated in the development of the concept of geometrical truth. Geometry arose in human practice from land measurement and demarcation. Like other physical truths geometrical truth was also culled from human experience and observation. In the hands of Euclid it received the axiomatic form.

Though the founders of geometry considered geometrical truths to be descriptions of physical reality, idealist philosophers tried to depict these as *a priori* truths. For example, Kant said: "...if a judgement carries with it strict and absolute universality, that is, admits of no possible exception, it is not derived from experience." He thus argued that geometrical truths are not founded on experience, and therefore their source is not outside the mind but within it.

Euclid was himself not satisfied with one of his postulates, namely, the postulate on parallels. This postulate states that to any given straight line from a point outside it one and only one parallel line can be drawn. This postulate (the so called Fifth postulate) was not as simple as the other postulates in his system. So he tried to derive this from the remaining postulates (axioms). All attempts to prove this postulate resulted in failure. So finally Euclid put this postulate up as a separate independent axiom.

Like all other sciences geometry went through a long period of hybernation during the dark ages. Problems of perspective in Renaissance art gave the motivation for the study of new rules of geometry. Mathematicians attacked the problem of parallels again, now trying various negations of the parallel postulate in the hope that this would give rise to contradictions. But surprisingly, the negation of the parallel postulate did not give the expected contradiction. Lobachewsky and Bolyai succeeded in showing that we can have a *consistent* geometry if we replaced the parallel postulate by the following postulate: "Through a point outside a given straight line *no parallel* can be drawn to it."

Another line of attack came from the physiologist Helmholtz who was trying to study the curvature of surfaces in connection with the anatomy of the eye and the construction of lenses. The great Gauss was also involved in a similar study of surfaces since he was making a geodetic survey for the construction of railway lines. Through a study of curvature Gauss and his student Riemann came to the conclusion that yet another geometry was possible if we made

some changes and replaced Euclid's postulate by the following postulate: "Through a point outside a line many parallels can be drawn to it."

Criterion of Mathematical Truth

The question arises: which proposition is true? Can one line be drawn, can no line be drawn, or can several lines be drawn? The law of excluded middle from formal logic tells us that between two opposite statements the truth must lie with one or the other, not in the middle somewhere. We have here three geometries each one of which has a proposition which opposed a corresponding proposition in the remaining two geometries. Which geometry is true? What is geometrical truth?

This contradiction was temporarily resolved by saying that truth in mathematics means non-contradictoriness. Each of the geometries may be taken as true since each is non-contradictory, or consistent. This is a new meaning of geometrical truth. The contradiction which arose in geometry was resolved by raising the notion of truth to a higher level and synthesising the opposing geometries into formal structures within the same mathematical umbrella, by stipulating that mathematics consists of examining the formal implications of the propositions taken as postulates. Non-contradictoriness was the only criterion of mathematical truth.

Russell said that mathematics does not say anything about the world. The saying that mathematics is like a blind man groping in a dark room for a black cat which is not there is attributed to him. But surprise was in store for the philosophers of mathematics when Einstein showed that the nature of spatial properties depended on the material structures present in the neighbourhood. In the neighbourhood of a massive gravitating body like the sun geometry is non-Euclidean, while in empty space far away from any such matter the geometry would be Euclidean. So we now have a physical criterion for examining the truth of geometries, not merely the criterion of being non-contradictory. Geometrical truth now becomes related to the properties of the physical world, and conforms to the old Greek idea of describing the properties of physical objects; except that it is truth at a higher level.

We have seen how one single notion of geometrical truth has undergone change, how at different stages contradictories have been united in a higher notion. Now if the geometers of the nineteenth century had been afraid of working with contradictions they would never have dared to work with the negation of the postulate of parallels. Everyone knew that Euclid's geometry was true. How then could one expect the negation of the parallel postulate to work? We are fortunate that scientists and mathematicians are capable of ignoring formal logic's exhortations regarding the law of excluded

middle when working out new theories. They instinctively think dialectically when they come across contradictions. Of course when they present their theories, they do so with the help of formal logic.

Resolution of a Contradiction

Zeno's paradox of the arrow in flight unites the proposition 'the arrow A is at B' with the proposition 'the arrow A is not at B'. For if the arrow is material it must be somewhere, say at the place B. In fact this contradiction expresses the fact of motion. To resolve this contradiction it is not enough to brush it aside. We must show how this contradiction properly expresses the fact of motion. Like every process a moving arrow combines two contradictory properties, its spatial properties and its dynamical properties. One property is its being located at and the other is its passing a point. It should be recognised that by having a position it is not deprived of its dynamical properties, and vice versa. The first proposition describes one aspect, its possessing location, and the second describes its other aspect, its dynamic nature, "The meaning of the terms in both the statements must be determined out of an integral act of thought, which can be expressed as follows: if A is located at B and A is not located at B, then A is in motion."[5] The example of the wave-particle nature of light and the example of infinitesimals both show how through a contradiction new truths are expressed.

At the same time the example of the introduction by Dirac of the delta function, throwing to the winds all accepted norms of definition of mathematical functions, shows how a major scientific thinker is prepared to ignore the formal requirements of logic. For logic works with cut and dried concepts. It cannot deal with *concepts in their formation.* Subsequent work by mathematicians to give rigorous definitions of the delta function and other 'generalised' functions also shows the role of formal logic in taking over concepts from working and practising scientises. This, however, is not to undermine the importance of logic in clearing up contradictions that arise due to verbal mistakes of semantic confusion,

Karl Marx did not write a separate book on dialectical logic. His ideas were developed in his numerous writings, and they are best seen in the masterly application of the dialectical method in analysing the concept of value. These ideas were further developed by Lenin. He enriched the dialectical method by adding his own analysis to materialist schools of his time

It is one thing to apply the rules of dialectics to scientific discoveries *after* they have been made. This would attract the criticism that one was fitting phenomena, post-facto, to suit a pet theory. The positive role of dialectics is seen when, using the dialectical method, one succeeds in looking for new facts of nature. The point is to stick one's neck out, to use the dialectical laws derived

from nature to look for new possible relations in nature. Lenin stuck his neck out when he said: "The electron is as *inexhaustible* as the atom, nature is infinite."[6] We must remember that this was the time when scientists like Mach were even doubting the existence of the atom. The present knowledge in the field of structures of elementary particles shows how Lenin was on the right track. Lenin's prediction that even the smallest known particle was itself a system with its inner contradictory movements, inexhaustible in its nature, shows how he had correctly applied dialectics to the study of nature.

In the above formulation Lenin also introduced a new law of dialectics, namely, the infinite depth of nature, the inexhaustibility of the processes of nature. It was on the basis of this principle of inexhaustibility of nature that the Marxist physicist David Bohm was able to develop his own theory of a causal quantum mechanics. John von Neumann had 'proved' a theorem showing the impossibility of ever having a causal quantum theory. David Bohm gave a death blow to this theorem in 1952 by constructing the first ever causal quantum theory. In developing such a thory he relied on what may be roughly described as forces acting at the sub-quantum level.

Black Holes

What does dialectics suggest for the further development of the stars beyond the neutron star stage? What can we expect when densities have increased to this level and the known sources of energy get depleted? What is the present state of theory in this area, and what does dialectical materialism suggest as possible lines of investigation?

Under certain conditions, after the star has exhausted all the above mentioned nuclear sources of energy, it starts shrinking under the pull of gravity. According to general relativity the geometry of space-time is decided by the structure of matter. For a spherical object of mass M, the geometry around it has been calculated from Einstein's field equations. This is called the Schwarzschild solution and it describes the geometry of space at any radial distance from the centre of the star. But the nature of this geometry is of one kind beyond a certain distance R called the Schwarzschild radius, and it is of a totally different kind within that distance R.

According to the present theory if the star shrinks to a radius smaller than this R, then there is only one way in which it can develop. The only movement possible is towards the centre. This means that the star would go on shrinking to a single point. The surface of the star would be trapped between two spherical surfaces N_1 and N_2 which are shrinking inward with the speed of light. But this includes not only the different particles of the star, which would travel to the centre, but also the light emitted by the star. The light would not come out of the surface of the star, since it is a trapped surface.

Such a star is called a black hole. Black holes would continue to exert gravitational attraction on other bodies but would not emit any light or energy. Black holes, according to the present theory, would have no contradictory motion and its only motion would be the inward mechanical motion of all its parts.

Black holes have not been spotted so far. They may be spotted in the future. But a great amount of qualitative study of its movement and development is called for before we apply the quantitative field equations of Einstein to these conditions. Einstein's field equations are derived from the fact that the gravitational power of attraction of a body (gravitational mass) and the measure of the *response* to forces of the same body (inertial mass) are equal. This principle of equivalence has been observed in a wide variety of situations. Einstein's revolutionary theory succeeded in uniting these opposites of attracting mass and responding mass, just as Marx's analysis of the concept of value united the opposites of relative value and equivalent value. But the unity of opposites is relative, temporary; it is their clash which is absolute. The unity of opposites in the concept of value is seen in its clash in the economic crises of capitalism, and the clash only ceases when the system of socialism is established when the law of value itself undergoes a change.

In the same way, it does not follow that the equality of inertial mass and gravitational mass which is observed in classical conditions should hold under the conditions within the interior of a star having a density of the order of a million million grams per cubic cm. Quantum conditions would have to be taken into account at this stage. The existence of trapped surfaces and singularities in the space-time geometries of general relativity shows that all is not well with the description of gravitation by general relativity.

It has been shown that such trapped surfaces exist even when the densities are not necessarily high if we take the usual Einstein interpretation of gravity as curvature of the space-time manifold. In fact the very concept of a manifold used in relativity may not be applicable in studying the structure of stellar collapse at this stage. The present approach is to start with the manifold structure described by the field equations and then to describe the motions as geodesic curves in this structure. Everything according to this approach is geometry. Now Alexandrov has shown how the geometrical structure is itself obtained by the physical processes. Using the physical processes, cause-effect relations in material motion, a geometry can be constructed (Alexandrov topology). Thus it is the motion that we have to study first, and then talk of the geometrical structures. This brings us back to the need to study *qualitatively* the properties of black holes before we give quantitative laws. This is an example of quality going into quantity. We can then expect internal contradictory aspects within the black holes as well. This is what dialectics suggests.

Further, Lenin's law of the inexhaustibility of nature should lead one to the law that matter *in motion* is inexhaustible. Inexhaustibility of motion would mean that by withdrawing energy it would not be possible to reduce matter to a state of motionlessness, where the internal motion is zero. This immediately suggests the possibility of inexhaustible reservoirs of energy in nature. The present theories of the nuclei of galaxies are not able to account for the tremendous outbursts of energy from these nuclei.

Gravitational fields appear to be seats of tremendous amounts of energy. This is reflected in the negative sign we give to the potential energy of gravitation. The Hoyle-Narlikar theory relates the formation of new galaxies to the withdrawal from this negative reservoir of energy.

The concept of negative energy is also used in some of the theories of the positron and in the calculation by Hawking regarding the way energy is withdrawn from a black hole through pair production. Negative energy, it appears, reflects the infinity of motion of matter. Under such a hypothesis, the problem of trapped surfaces and singularities in the space-time manifold may be successfully tackled. It would mean that the black hole is not necessarily a one way traffic of particles and energy going towards the centre, but is a process with its own inner contradictions.

The principle of contradiction suggests that at some stage gravitational attraction would turn into repulsion under certain conditions. Engels had said a century ago (in 1890): "Where there is attraction, it must be complemented by repulsion". Narlikar said the following regarding the Hoyle-Narlikar theory: "If we examine the motion of a test particle...we find that it is first attracted by the isolated particle. But when the test particle gets very close to the isolated particle *it is repelled.* ... If gravitation changes sign and attraction changes to repulsion at very close range, this may explain why, for example, the massive galactic nuclei seem to be exploding rather than imploding."[7]

Attraction changing to repulsion is a manifestation of the law of struggle and unity of opposites. The black hole, if discovered, would be one more testing place for this dialectical law.

1 Maurice Cornforth, *Marxism and the Linguistic Philosophy*, London, Lawrence and Wishart, 1965, page 296.

2 Niel Smith, "Symptomatic Silence in Althusser: The Concept of Nature and the Unity of Science", *Science and Society*, p 77·

3 Karl Marx, *Grundrisse*, The Pelican Marx Library, 1973, p 817.

4 A S Bagomolov, *Dialectical Contradiction and its Solution in Philosophy in the U S S R*, Moscow, Progress Publishers, 1977, p 141.

5 *Ibid*, p 152.

6 V I Lenin, *Materialism and Empiriocriticism*, Moscow, Progress Publishers, 1979, p 243

7 J V Narlikar, *The Structure of the Universe*, Oxford University Press, 1978, p 171